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Pterional Approach: Operative Technique and Surgical Applications

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Learning Objectives: *After participating in this CME activity, the neurosurgeon should be better able to:*

1. *Distinguish the anatomic elements exposed in the pterional approach (PA).*
2. *Compare the pathologic entities that can be treated via the PA.*
3. *Prepare a systematic description of the steps to follow to perform a PA in a simple, practical, and systematic way.*

Fronto-temporo-sphenoidal craniotomy, best known as the pterional approach (PA), is one of the most widely used approaches in cranial surgery. This is because, through the sylvian fissure (SF), it allows access to the subarachnoid cisterns, the insula, and the mesial temporal lobe. Even nowadays, the PA it is still a published topic, although it was first described more than 40 years ago by Yaşargil. Over time, multiple variants were added to the PA, including minipterional, transzygomatic, and orbitozygomatic approaches. The PA takes the pterion as the midpoint, thus exposing a small section of the lateral part of the frontal, parietal, temporal (squamous), and sphenoid (greater wing) bones. In this way, the PA makes it possible to expose, through the SF and the lateral subfrontal via, the insula, the basal ganglia, the mesial temporal region, the supra and parasellar area, a large part of the anterior and middle fossa, and the basal cisterns.

The PA is based on exposure and opening of the SF. Therefore, accurate anatomic knowledge of the SF is necessary, as well as the techniques to open it; when separating both opercula, upper or frontal and lower or temporal, the neurosurgeon is able to approach multiple anatomic structures that were previously described.

Positioning

Positioning is one of the most important parts of an approach, because placing the patient at an adequate angle will provide a better surgical field to the lesion and a lesser amount of brain retraction. The patient is placed in the supine position, with the head fixed with a head clamp. A solitary pin is placed on the base of the ipsilateral mastoid process, making sure that it is not too anterior, so that it neither injures the external auditory meatus nor touches the skin of the pinna. The double pins are placed over the superior temporal line (STL), contralaterally. Avoid placing it in the temporal squama so that it does not injure the muscle or fracture the temporal bone.

Once the head clamp has been placed, the head must be positioned with the aim to fulfill several objectives:

1. Facilitate venous drainage: this is achieved by raising the head some degrees above the thorax;
2. Obtain the best angle to approach the lesion: this is done by rotating the head toward the contralateral side 10 to 50 degrees (depending on the pathologic entity being treated);

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Category: General Neurosurgery

Key Words: Craniotomy, Pterional approach, Surgery, Sylvian fissure

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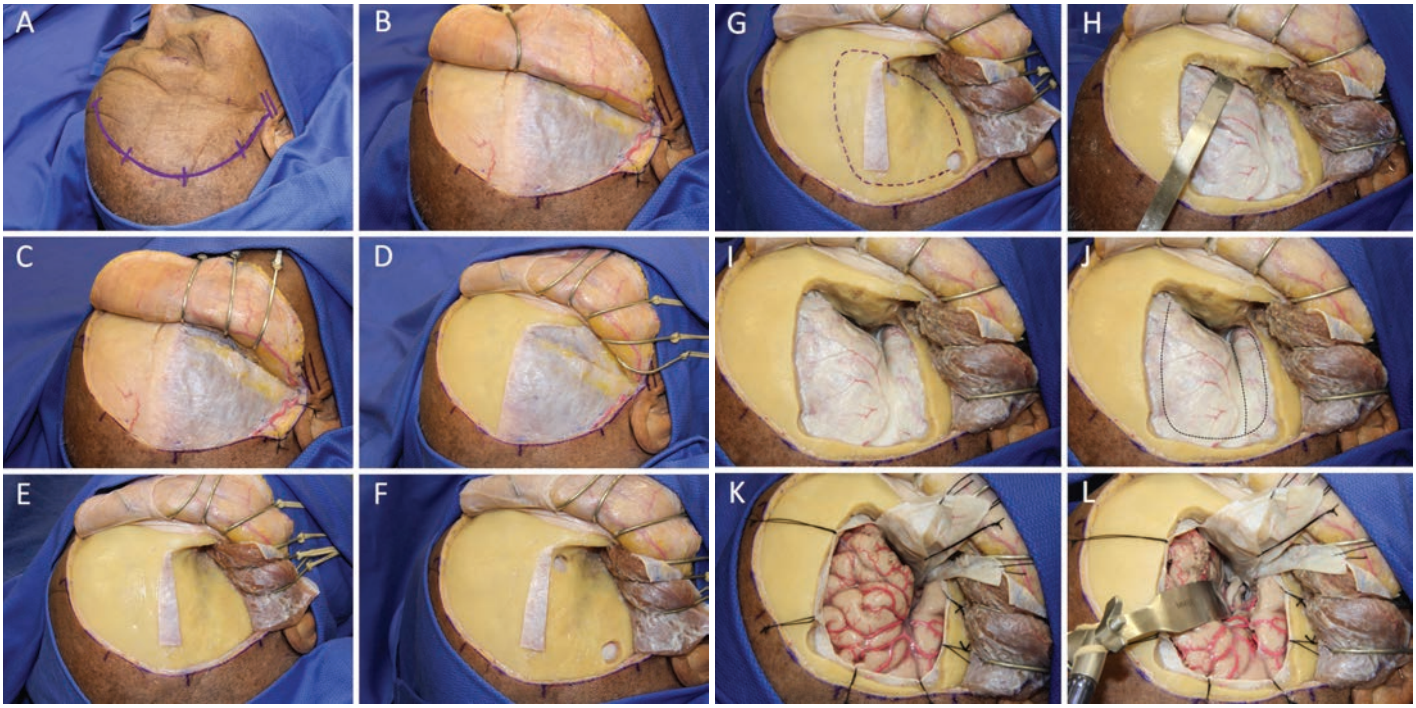

Figure 1. ***A***, The incision starts at the level of the upper margin of the zygomatic arch, 1 cm anterior to the tragus, and extends behind the hairline up to the midline. ***B***, Subgaleal dissection is performed until the fat pad above the temporal fascia is seen. ***C*** and ***D***, Interfascial dissection allows preservation of the frontal branch of the facial nerve; thus, the frontozygomatic suture is exposed. ***E***, The TM is incised and elevated from the bone, exposing the pterion and the squamous suture, while a cuff of the muscle is left attached to the bone, allowing a more cosmetic reconstruction. ***F***, Two holes are created with trephines, one just behind the frontozygomatic suture, and the other in the lowest and most posterior part of the exposed section of the temporal squama. ***G***, A dotted line marks the bone flap, which must be of adequate size to approach and visualize the lesion with the least possible brain retraction. ***H*** and ***I***, Drilling of the anterior part of the approach. First, the entire frontal bone is lowered, until a small bone sheet is left at the level of the orbital rim and roof. Finally, the sphenoid wing is drilled until the lateral limit of the superior orbital fissure is approached. ***J***, The dural opening, in 2 flaps, is demarcated with a dotted line. ***K***, The dural opening was already performed. ***L***, The SF has been opened, and the basal cisterns are exposed.

3. Avoid excessive parenchymal traction: this is achieved by extending the head 10 to 30 degrees, using gravity to displace the brain downward; and
4. Maintain the SF parallel and horizontal to the surgeon: this is done by rotating the neck toward the contralateral shoulder.

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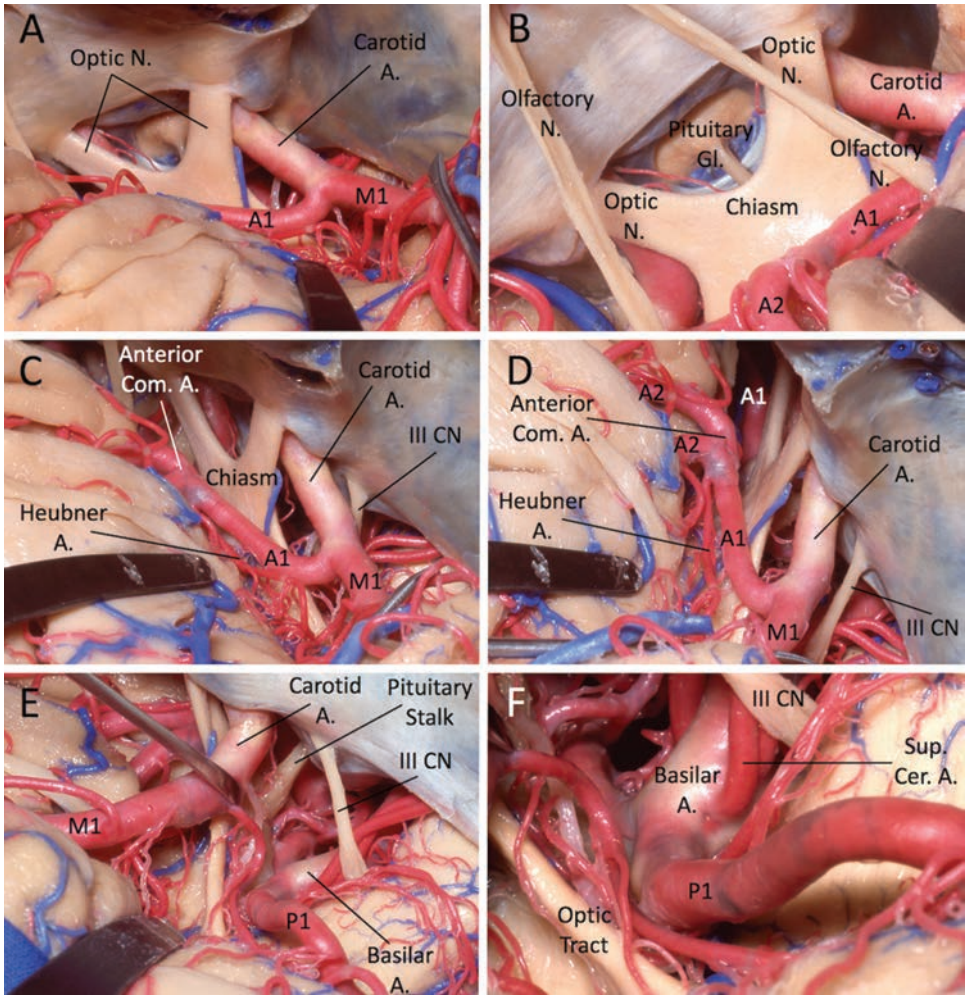

Figure 2. Anatomic elements that may be exposed by means of the PA. ***A***, The internal carotid artery, M1 segment of the middle cerebral artery, and A1 segment of the anterior cerebral artery have been exposed, as well as both optic nerves. ***B***, More anterior view, by a subfrontal approach. Both olfactory nerves can be observed, the optic nerves and chiasm, and the pituitary gland and its stem. The supraclinoid carotid artery and A1 and A2 segments of the anterior cerebral artery are exposed. ***C***, More posterior view shows the third cranial nerve in the cavernous sinus roof and the Heubner artery. ***D***, This view allows observation of both A1 segments of the anterior cerebral artery, the anterior communicating artery, the Heubner artery, both optic nerves, and the third cranial nerve. ***E***, More posterior view showing that the internal carotid artery has been inclined anteriorly; observe the pituitary stalk, the third cranial nerve in its entire trajectory, the basilar artery, and the P1 segment of the posterior cerebral artery. ***F***, With a higher magnification and with a posterior orientation, the PA allows access to the basilar bifurcation, the P1 segment of the posterior cerebral artery, the optic tract, and the third cranial nerve.

Incision

A curved line is drawn, starting 1 cm anterior to the tragus, just at the level of the upper border of the zygomatic arch, until the midline. The incision runs 1 to 2 cm posterior to the hair insertion line (Figure 1A). It is advisable to make perpendicular markings with a waterproof fiber 3 cm apart, which will assist in correct skin coping during the closing stage. The incision is infiltrated with lidocaine 2% with epinephrine along the entire marking, so as to produce analgesia and reduce bleeding. Then, the skin and the subcutaneous tissue are incised from the midline toward the zygomatic arch. The incision is deepened, medial to the STL until the pericranium. Lateral to the STL, the incision deepens until the superficial temporal fascia (STF) is reached. In the same way, following the lax subcutaneous tissue plane, dissection proceeds.

In the lowest part of the incision (Figure 1B), it is necessary to expose the superficial temporal artery (STA). The STA may have a bifurcation below or above the upper border of the zygomatic arch; if the bifurcation is below it, it is not necessary to sacrifice any arterial branch. However, if the STA bifurcation is above the upper border of the zygomatic arch, it is necessary to coagulate and cut the posterior branch, preserving the anterior branch that is going with the flap. In this way, dissection proceeds symmetrically forward to approximately 2 cm behind the orbital rim.

Interfascial Dissection

Two centimeters behind the orbital rim, at the level of the temporalis muscle (TM), it is necessary to deepen the dissection, so as to conserve the frontotemporal branch of the facial nerve, which runs externally to the superficial layer of the STF. Thus, an incision 2 cm posterior to the orbital rim is performed, cutting the superficial layer and the interfascial fat pad. Interfascial dissection runs from the STL to the zygomatic arch (Figure 1C), as dissection is easier in the superior part (near the STL) than in the inferior part (near the zygomatic arch). There are 2 fat pads in the anterior part of the TM. One of them is superficial to the superficial layer of the STF. The other lies between the superficial and deep layers of the STF (interfascial fat). Identifying the interfascial vein, which runs oblique downward and backward through the interfascial fat, is of great help to confirm the location within the interfascial fat pad. It is necessary to coagulate and cut the interfascial vein to move forward, searching for the orbital rim. Finally, the skin and the subcutaneous tissue flap are pulled with hooks in an anterolateral direction (Figure 1D).

Temporalis Muscle Dissection

The fascia of the TM is incised with a scalpel, from front to back, 0.5 cm below the STL, leaving a fascia cuff stuck to the bone, at the level of the STL, to suture the TM to that cuff during closure. Furthermore, it is necessary to cut the

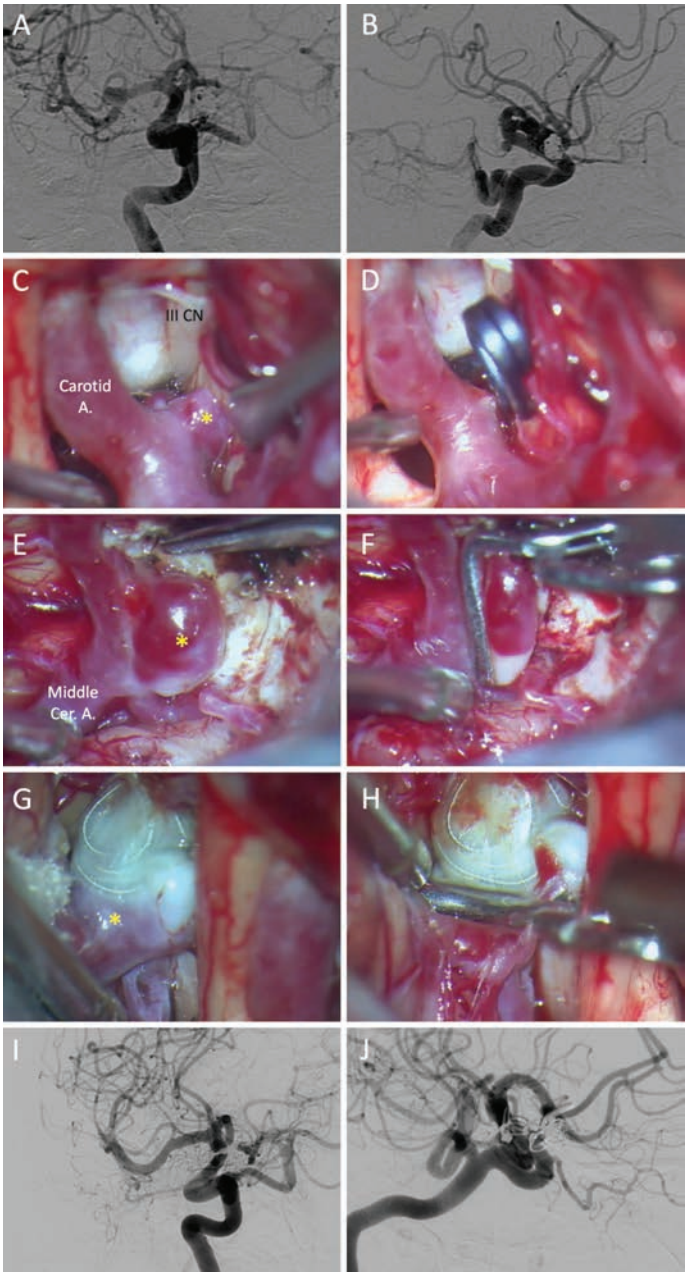

Figure 3. A patient with multiple aneurysms. ***A*** and ***B***, Preoperative angiograms. ***C*** and ***D***, Intraoperative images showing clipping of the choroidal aneurysm. ***E*** and ***F***, Clipping of the middle cerebral artery aneurysm. ***G*** and ***H***, Clipping of the anterior communicating aneurysm, embolized and recanalized. ***I*** and ***J***, Postoperative angiograms showing complete obliteration of the aneurysms.

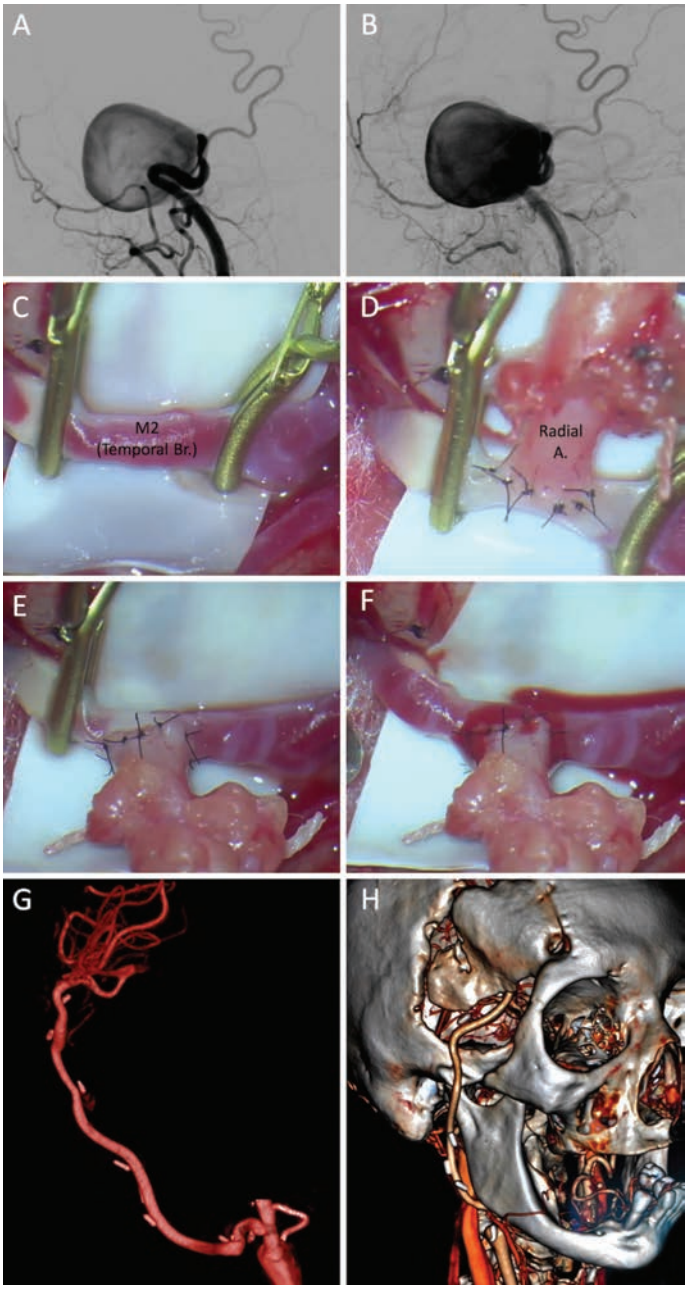

Figure 4. Giant aneurysm of the carotid artery. ***A*** and ***B***, Preoperative angiograms. ***C*** through ***F***, Intraoperative images of high-flow bypass, with an anastomosis between the radial artery and the M2 segment of the middle cerebral artery. ***G***, Control demonstrated by a 3D digital angiogram. ***H***, CT angiogram shows disappearance of the aneurysm and bypass permeability.

TM anteriorly from the front in the orbital rim, until 2 cm below the frontozygomatic suture, and toward the back, to dissect the TM from the STL until 2 cm from below the squamous suture. Then, retrograde subperiosteal dissection proceeds (Oikawa's technique) from inferoposterior to superoanterior. Attempts should be made to preserve the deep temporal fascia as best as possible. The use of monopolar cautery for TM detaching is not recommended, because it alters and damages the nerves and vessels, which run through the deep temporal fascia, producing postoperative TM atrophy. Finally, the muscular flap is pulled laterally (Figure 1E).

Craniotomy

When planning a craniotomy, 2 points are important to consider: (1) avoiding the laceration or the opening of the dura mater; and (2) performing a craniotomy of adequate size to approach and visualize the lesion with the least possible brain retraction. It is advisable to make just 2 holes with trephines. The older the patient, the more holes are necessary, because the dura mater is adhered to the internal side of the bone. Therefore, one hole is created just behind the frontozygomatic suture, and the other hole in the lowest and most posterior part of the exposed section of the temporal squama (Figure 1F).

Before performing the craniotomy, it is vital to separate the dura mater from the bone with a dissector. In this way, we begin our cut from the anterior-superior hole toward the posterior-inferior one. Then, to deal with the inferior part of the osseous cut, we use a 3- to 4-mm-thick bit until both holes are joined from below (Figure 1G). This is because the lesser wing of the sphenoid bone is located at the level of the pterion, which makes it very difficult to advance with the craniotomy attachment.

Once the bone flap has been removed, we proceed to fix the dura mater in the cranial periphery, so as to prevent extradural hemorrhage. To this aim, every 3 cm we proceed to cut diagonal holes (from the external table to the diploe), and then dural fixation is performed with nonabsorbable suture.

The next, highly important step is drilling of the anterior part of the approach. First, the entire orbital rim and the roof are flattened, until a small osseous lamina is left at the level of the superior orbital wall (Figure 1H and I). Finally, the sphenoid wing is drilled until the lateral limit of the superior orbital fissure is reached. In short, the objective is to eliminate any bony prominence so as to obtain better visualization of the basal structures.

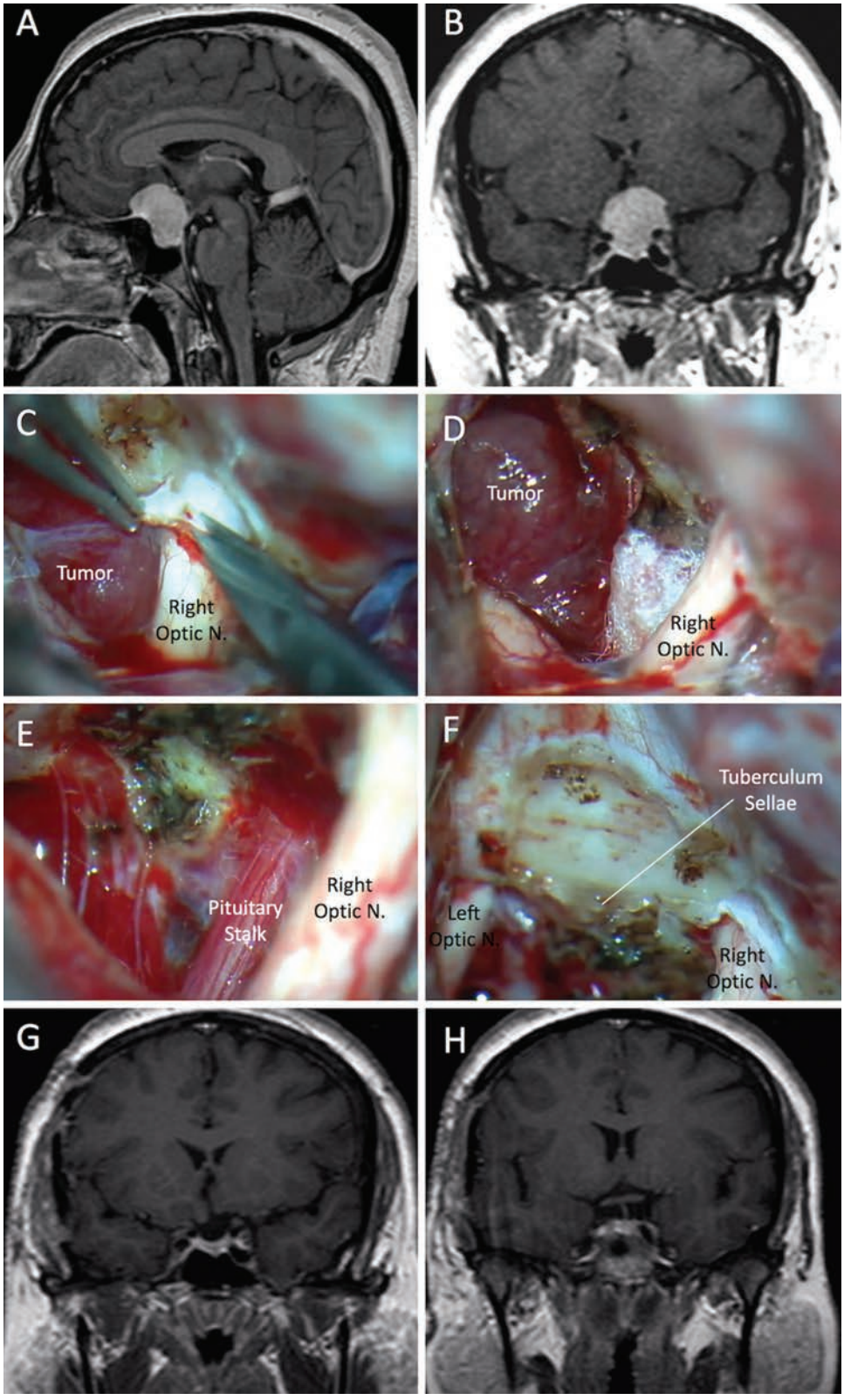

Figure 5. Tuberculum sellae meningioma. ***A*** and ***B***, Preoperative T1-weighted, contrast-enhanced MR image. ***C*** and ***D***, Intraoperative view of the lesion by means of PA. ***E*** and ***F***, Intraoperative images postresection. ***G*** and ***H***, Postoperative MR images showing total resection.

Dural Opening

When opening the dura mater, the aim is to use most of the previous bone removal, mainly at the level of the lesser sphenoid wing. For this reason, we suggest that the dura mater should be opened with 2 flaps, one frontal and the other temporal. Therefore, we begin the dural opening at the anterosuperior level and, following the limits of the craniotomy, complete the incision in a curvilinear manner until we have reached the anteroinferior point (Figure 1J and K). Then, we make a transversal incision after the SF, pointing at the superior orbital fissure. In this way, the frontal and temporal dural flaps are pulled forward. Once the dura mater has been opened, the following structures must be exposed: middle and inferior frontal gyrus, superior temporal gyrus, and SF (Figure 1L).

Closure

During closure, at dural, cranial and soft tissue levels, hemostasis and hermetic sealing are key points to consider so as to avoid future complications. The dura mater is hermetically closed, using pericranium or synthetic graft if

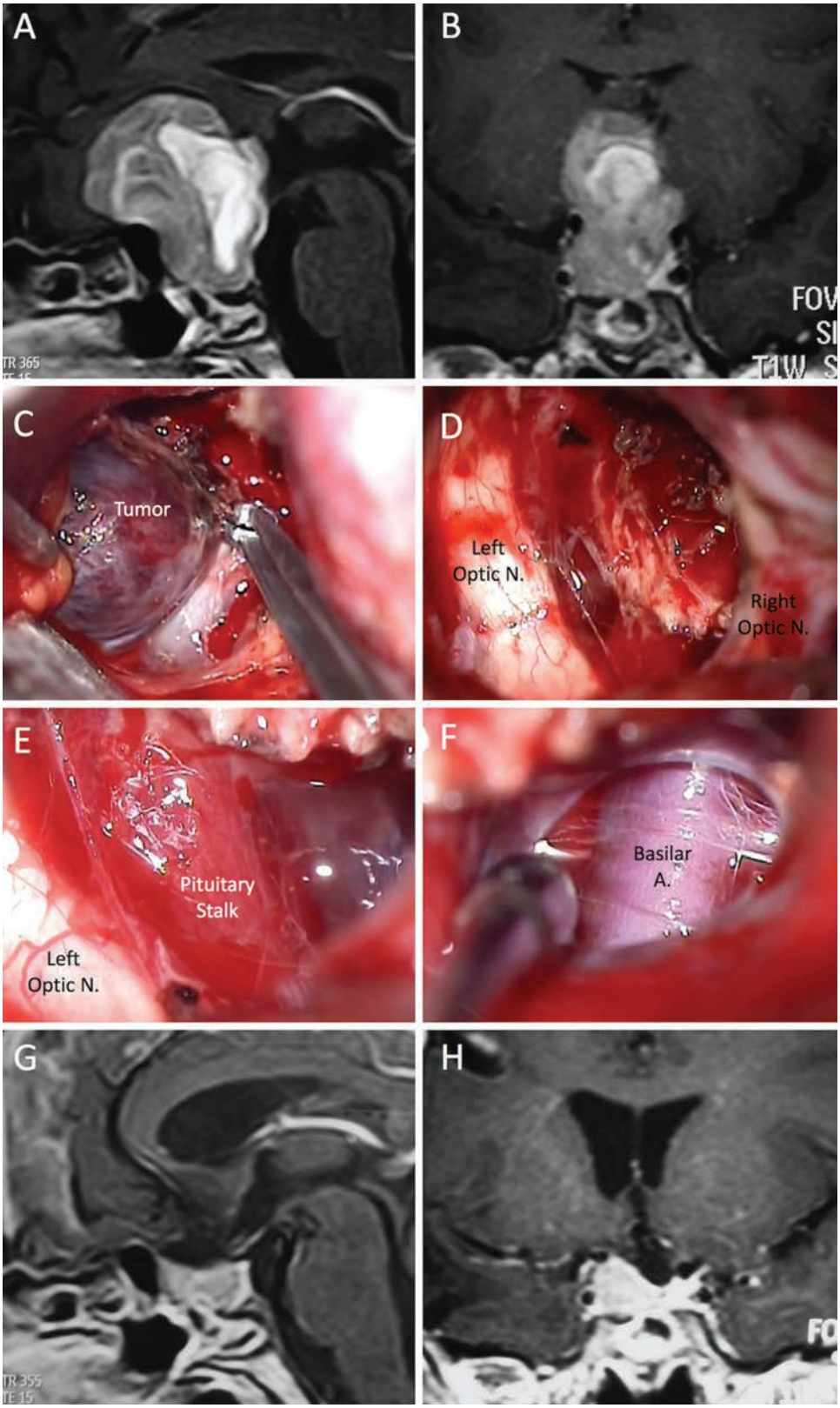

Figure 6. Pituitary adenoma. ***A*** and ***B***, Preoperative T1-weighted, contrast-enhanced MR images. ***C*** and ***D***, Intraoperative exposure by PA and tumor resection. ***E***, Intraoperative photograph showing the pituitary stalk. ***F***, Intraoperative photograph showing the basilar artery after tumor resection. ***G*** and ***H***, Postoperative MR images.

necessary. We proceed to place a bone flap and fix it with miniplates or nonabsorbable suture. The TM is anatomically positioned, and the temporal fascia is sutured with the muscular cuff that was left when the muscle was dissected. The galea and the subcutaneous tissue are closed with absorbable suture. Then, the skin is closed with nonabsorbable suture or staples.

Application of the Approach

The PA allows the neurosurgeon to treat patients with a wide range of pathologic entities (Figures 2–7). These may be grouped as follows:

1. Brain aneurysms (Figure 3): practically all aneurysms of the anterior circulation (paraclinoid, posterior communicating, anterior choroidal, carotid bifurcation,

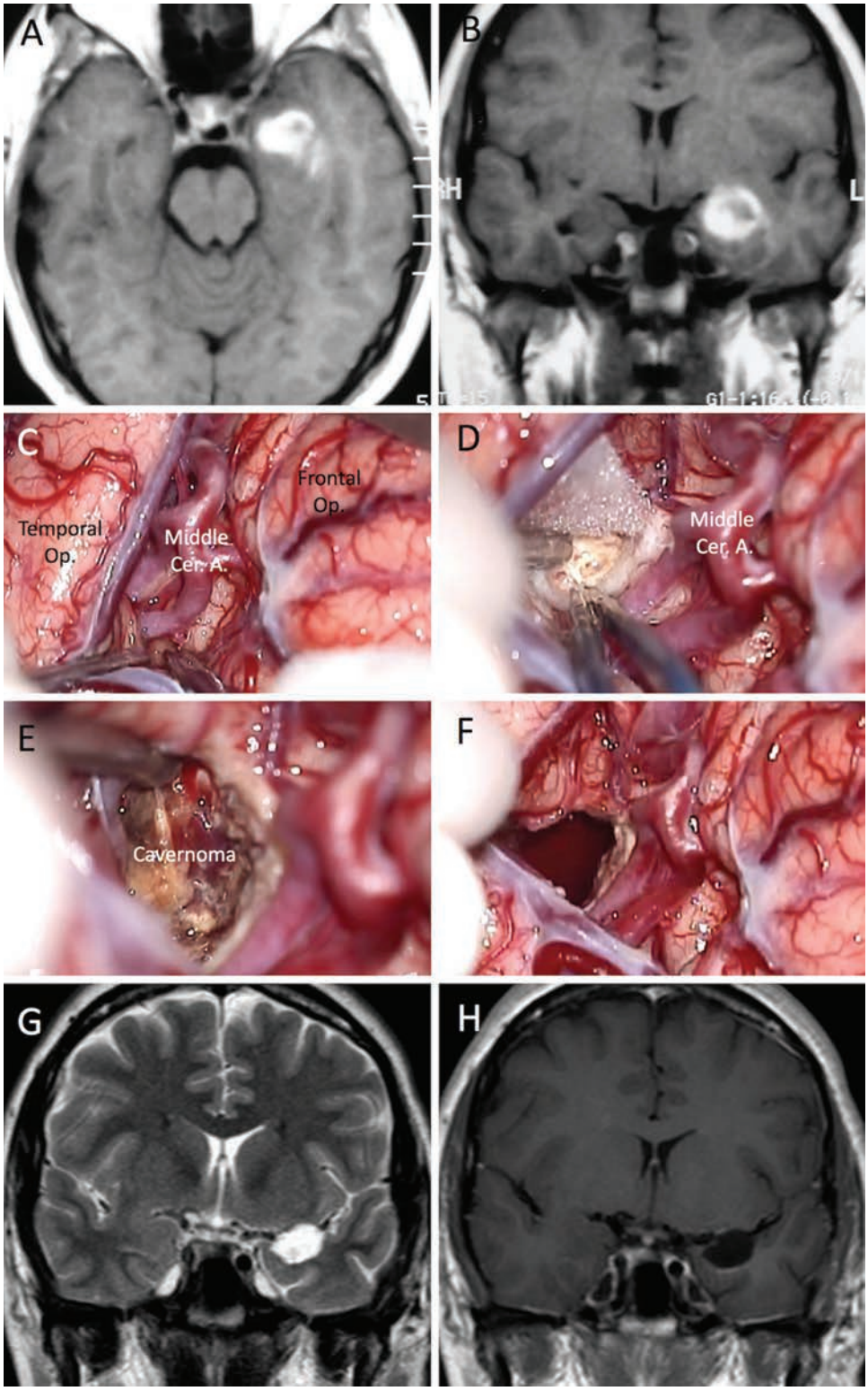

Figure 7. Cavernoma of the mesial temporal region. ***A*** and ***B***, Preoperative MR images. ***C***, PA and opening of the SF. ***D***, Access to the lesion through the limiting sulcus of insula. ***E*** and ***F***, Exposure and resection of the cavernoma. ***G*** and ***H***, Postoperative MR images.

anterior communicating, and sylvian), including several contralateral aneurysms. In addition, some aneurysms of the posterior circulation (basilar bifurcation, superior cerebellar, and proximal posterior cerebral).

2. Arteriovenous malformations and cavernomas (Figure 7): located in the frontal or temporal opercula, frontobasal region, insula and the anterior portion of the mesial temporal region.
3. Extra-axial tumors (Figures 5 and 6): meningiomas of the tuberculum sellae, clinoid meningiomas, macroadenomas with supra-/parasellar extension, craniopharyngiomas.
4. Intra-axial tumors: insular gliomas, mesial temporal region gliomas.
5. Revascularization: extraintracranial cerebral bypass (Figure 4).
6. Epilepsy surgery: selective amygdalohippocampectomy.

Conclusion

The PA is a current technique with modifications that should not affect its basic principles. Careful application of

the PA allows access a wide number of anterior and middle cranial base pathologic entities. Knowing how to perform the PA is an essential part of every neurosurgeon's arsenal.

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1. Incision in a PA proceeds from the lower border of the zygomatic arch to the contralateral pupillary line.

True or False?

2. In young patients, it is recommended to create 5 trephine holes.

True or False?

3. The lesser sphenoid wing must be drilled to the lateral border of the superior orbital fissure.

True or False?

4. Rotation of the head toward the contralateral side must always be 50 degrees.

True or False?

5. The interfascial vein is an important anatomic element in interfascial dissection.

True or False?

6. Interfascial dissection allows preservation of the frontal branch of the facial nerve.

True or False?

7. The use of monopolar cauterization to dissect the TM is recommended.

True or False?

8. The PA allows access only to anterior circulation aneurysms.

True or False?

9. The PA, allows access to the anterior sector of the mesial temporal region.

True or False?

10. The Heubner artery cannot be exposed with a PA.

True or False?